§ 94.67 Frequency tolerance.

Stations in this service shall maintain the carrier frequency of each authorized transmitter to within the following percentage of the assigned frequency:

Frequency band (MHz)	Tolerance as percentage of assigned frequency
928-929	[1]0.0005
932-932.5, 941-941.5	0.00015
932.5-935, 941.5-944	0.00025
952-960	([2])([3])
1,850 to 1,990	0.002
2,130 to 2,150	0.001
2,150 to 2,160	0.001
2,180 to 2,200	0.001
2,450 to 2,500	0.001
6,425 to 6,525	0.005
6,525 to 6,875	0.005
10,550 to 10,680	[4]0.0003
12,200 to 13,150	[3]0.005
13,200 to 13,250	0.03
17,700 to 18,820	[1]0.003
18,820 to 18,920	0.001
18,920 to 19,700	[1]0.003
21,200 to 23,600	[4]0.03
31,000 to 31,300	0.03
31,300 to 40,000	0.03

[1] Transmitters authorized prior to January 1, 1981 at remote sites as part of a central protection alarm system are permitted a tolerance of .002%. Such stations may continue to operate as licensed until January 1, 1991.

[2] For exceptions see § 94.90.

[3] To be specified in authorization.

of modulation, and transmission characteristic, consistent with efficient use of the spectrum and good engineering practice, except that Type B, damped-wave emission will not be authorized.

[48 FR 32586, July 18, 1983]

§ 94.71 Emission and bandwidth limitations.

(a) Each authorization issued to a station operating in this service will show, as a prefix to the emission classification, a figure specifying the necessary bandwidth.

(b) The maximum bandwidth which will be authorized per frequency assigned is set out in the table which follows. Regardless of the maximum authorized bandwidth specified for each frequency band, the Commission reserves the right to issue a license for less than the maximum bandwidth if it appears that a lesser bandwidth would be sufficient to support an applicant's intended communications.

Frequency band MHz	Maximum authorized bandwidth
928-929	12.5, 25 kHz [1] [2]
932-932.5, 941-941.5	12.5 kHz [1]
932.5-935, 941.5-944	25, 50, 100, 200 kHz [1]
952-960	12.5, 25, 50, 100, 200

* For frequencies listed in § 94.65(a)(1), consideration will be given on a case-by-case basis to authorizing bandwidths up to 50 kHz.

(c) The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:

(1) When using transmissions other than those employing digital modulation techniques:

(i) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth, at least 25 decibels;

(ii) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth, at least 35 decibels;

(iii) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth at least 43 plus 10 $\log_{10}$ (mean output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

(iv) On any frequency above 40,000 MHz the carrier harmonics of any systems operating under the provisions of § 94.91 shall be attenuated at least 33 plus 10 log 10 (mean output power in watts) decibels.

(2) When using transmissions employing digital modulation techniques:

(i) Except as noted in paragraph (c)(3) of this section, for operating frequencies below 15 GHz, in any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth: As specified by the following equation but in no event less than 50 decibels: $A=35+0.8(P-50)+10\log_{10}B$. (Attenuation greater than 80 decibels is not required.)

Where:

A = attenuation (in decibels) below the mean output power level

P = percent removed from the carrier frequency

B = authorized bandwidth in MHz.

(ii) For operating frequencies above 15 GHz, in any 1 MHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 250 percent of the authorized bandwidth: As specified by the following equation but in no event less than 11 decibels: $A=11+0.4(P-50)+10\log_{10}B$. (Attenuation greater than 56 decibels is not required.)

(iii) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus 10 $\log_{10}$(mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation.

(iv) On any frequency above 40,000 MHz the carrier harmonics of any systems operating under the provisions of § 94.91 shall be attenuated at least 33 plus 10 log 10 (mean output power in watts) decibels.

(3) When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a 12.5 kHz bandwidth, the power of any emission shall be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule:

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (fd in kHz) of more than 2.5 kHz up to and including 6.25 kHz: At least 53 $\log_{10}$ (f_d/2.5) decibels;

(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 6.25 kHz up to and including 9.5 kHz: At least 103 $\log_{10}$ (f_d/3.9) decibels;

(iii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 9.5 kHz up to and including 15 kHz: At least 157 $\log_{10}$ (f_d/5.3) decibels;

(iv) On any frequency removed from the center of the authorized bandwidth by a displacement frequency greater than 15 kHz: At least 50 plus 10 $\log_{10}$(P) or 70 decibels, whichever is the lesser attenuation.

(4) When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a bandwidth greater than 12.5 kHz, the power of any emission shall be attenuated below the unmodulated carrier power of the trans-

mitter (P) in accordance with the following schedule:

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz up to and including 10 kHz: At least 83 $\log_{10}$ (f_d/5) decibels;

(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz up to and including 250 percent of the authorized bandwidth: At least 116 $\log_{10}$ (f_d/6.1) decibels or 50 plus 10$\log_{10}$(P) or 70 decibels, whichever is the lesser attenuation;

(iii) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 plus 10 $\log_{10}$(output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

(5) For Digital Transmission System channels operating in the 10,550-10,680 MHz band:

(i) In any 4 kHz band, the center frequency of which is removed from the edge of the Digital Termination System (DTS) channel by to up and including 1.125 the DTS subchannel bandwidth: as specified by the following equation but in no event be less than 50 + 10 $\log_{10}$ N decibels.

$A = 50 - 0.0333\ (F - 0.5B) + 10\ \log_{10}$ N decibels

Where:

A = Attenuation (in decibels) below mean output power level contained within the DTS channel for a given polarization.
B = Bandwidth of DTS channel (in kHz).
F = Absolute value of the difference between the center frequency of the 4 kHz band measured and the center frequency of the DTS channel (in kHz).
N = Number of active subchannels of the given polarization within the DTS channel.

(ii) In any 4 kHz band within the authorized DTS band, the center frequency of which is removed from the center frequency of the channel by more than the sum of 50% of the DTS channel bandwidth plus 1.125 times the subchannel bandwidth: as specified by the following equation but in no event less than 80 decibels.

$A = 80 + 10\ \log_{10}$ N decibels

(iii) In any 4 kHz band the center frequency of which is outside the authorized DTS band:

At least 43 + 10 $\log_{10}$ (mean output power in watts) decibels.

(6) For Digital Termination System channels operating in the 17,000-19,700 MHz band:

(i) In any 4 kHz band, the center frequency of which is removed from the frequency of the center of the DTS channel by more than 50 percent of the DTS channel bandwidth up to and including 50 percent plus 500 kHz: as specified by the following equation but in no event be less than 50 + 10 $\log_{10}$ N decibels.

$A = 50 + 0.06\ (F - 0.5B) + 10\ \log_{10}$ N decibels

Where:

A = Attenuation (in decibels) below output power level contained within the DTS channel for a given polarization.
B = Bandwidth of DTS channel (in kHz).
F = Absolute value of the difference between the center frequency of the 4 kHz band measured and the center frequency of the DTS channel (in kHz).
N = Number of active subchannels of the given polarization within the DTS channel.

(ii) In any 4 kHz band within the authorized DTS band, the center frequency of which is removed from the center frequency of the DTS channel by more than 50% of the channel bandwidth plus 500 kHz: as specified by the following equation but in no event less than 80 decibels:

$A = 80 + 10\ \log_{10}$ N decibels

(iii) In any 4 kHz band the center frequency of which is outside the authorized DTS band:

At least 43 + 10 $\log_{10}$ (mean output power in Watts) decibels.

(d) When a spurious emission results and causes harmful interference, the Commission may require appropriate technical changes in equipment to alleviate the interference.

(e) The emission of an unmodulated carrier is prohibited except for test purposes as required for proper station and system maintenance.

(Secs. 4, 303, 48 Stat., as amended, 1066, 1082, 1083 (47 U.S.C. 154; 303, 307); secs. 4(i), 301 and 303(r), Federal Communications Act

of 1934, as amended, 47 U.S.C. 4(i), 301 and 303(r))

[40 FR 20928, May 13, 1975]

EDITORIAL NOTE: For FEDERAL REGISTER citations affecting § 94.71, see the List of CFR Sections Affected in the Finding Aids section of this volume.

§ 94.73 Power limitations.

(a) On any authorized frequency, the average power delivered to an antenna in this service shall be the minimum amount of power necessary to carry out the communications desired. Application of this principle shall include, but not limited to requiring a licensee who replaces one or more of his antennas with larger antennas to reduce his antenna input power by an amount appropriate to compensate for the increased primary lobe gain of the replacement antenna(s). In no event shall the average equivalent isotropically radiated power (EIRP) as referenced to an isotropic radiator, exceed the values specified below. Further, the output power of a transmitter on any authorized frequency in this service shall not exceed the following:

Frequency band (MHz)	Maximum allowable transmitter power		Maximum allowable EIRP [1]	
	Fixed (W)	Mobile (W)	Fixed (dBW)	Mobile (dBW)
928 to 929	5.0		+17	
932-932.5			−17	
932.5-935	20.0		+40	
941-941.5			+30	
941.5-944	20.0		+40	
952 to 960	[2] 20.0		[3] +40	
1,850 to 1,990	20.0		+45	
2,130 to 2,150	20.0		+45	
2,150 to 2,160	20.0		[3] +45	
2,180 to 2,200	20.0		+45	
2,450 to 2,500	20.0		+45	
6,425 to 6,525		20.0		+35
6,525 to 6,875	20.0		+50	
10,550 to 10,565	10.0		+40	
10,565 to 10,615	([4])			
10,615 to 10,630	10.0		+40	
10,630 to 10,680	([4])			
12,200 to 12,700 [5]	10.0		[6] +50	
12,700 to 13,250	10.0		+50	
17,700 to 18,600	10.0		+55	
18,600 to 18,800	[7] 10.0		+35	
18,800 to 19,700	10.0		+55	
21,200 to 23,600 [5]	10.0		+40	
31,000 to 31,300	0.05	0.05		
38,600 to 40,000	10.0		+40	

[1] Peak envelope power shall not exceed five times the average power.

[2] For multiple address operations, see § 94.65(a)(1)(iv). When an *omnidirectional* transmitting antenna is authorized in the 2150–2160 MHz band, the maximum power shall be 60dBm.

[3] Also see § 94.77.

[4] Except in the bands 12.500–12.700 MHz, the maximum allowable EIRP is specified in § 94.77.

[5] The output power of a Digital Termination System node' transmitter shall not exceed 0.5 watts per 250 kHz. The output power of a Digital Termination System user transmitter shall not exceed 0.04 watts per 250 kHz. The transmitter power in terms of the watts specified is the peak envelope power of the emission measured at the associated antenna input port. The operating power shall not exceed the authorized power by more than 10 percent of the authorized power in watts at any time.

[6] Maximum power delivered to antenna shall not exceed − 3 dBW.

[7] Remote alarm units that are part of a multiple address central station protection system are authorized a maximum of 2 watts.

§ 94.75 Antenna limitations.

(a) Except where omnidirectional operation is specifically provided for under this part, each station in this service shall employ directional antennas with the center of the major lobe of radiation directed toward the receiving station with which it communicates or, if the path employs a passive repeater, to the center of that reflector.

(b) Directional antennas shall meet the performance standards (for parallel polarization) indicated in the following table:

ANTENNA STANDARDS

Frequency (MHz)	Category	Maximum beamwidth to 3 dB points (included angle in degrees)	Minimum antenna gain (dBi)	Minimum radiation suppression to angle in degrees from centerline of main beam in decibels						
				5° to 10°	10° to 15°	15° to 20°	20° to 30°	30° to 100°	100° to 140°	140° to 180°
932.5 to 935	A	14.0	NA	.....	6	11	14	17	20	24
941.5 to 944	B	20.0	NA	.....	.....	6	10	13	15	20
952 to 960 [1] [4]	A	14.0	NA	.....	6	11	14	17	20	24
	B	20.0	NA	.....	.....	6	10	13	15	20
1,850 to 2,500 [2]	A	5.0	NA	12	18	22	25	29	33	39
	B	8.0	NA	5	18	20	20	25	28	36
6,525 to 6,875	A	1.5	NA	26	29	32	34	38	41	49
	B	2.0	NA	21	25	29	32	35	39	45
10,550 to 10,565 [6]	A	3.4	34.0	20	24	28	32	35	55	55
	B	3.4	34.0	20	24	28	32	35	35	39
10,565 to 10,615 [3]	NA	360	NA	NA	NA	NA	NA	NA	NA	NA
10,615 to 10,630	A	3.4	34.0	20	24	28	32	35	55	55
	B	3.4	34.0	20	24	28	32	35	35	39
10,630 to 10,680 [3]	NA	NA	34.0	20	24	28	32	35	36	36
12,200 to 13,250 [6]	A	1.0	NA	23	28	35	39	41	42	50
	B	2.0	NA	20	25	28	30	32	37	47
17,700 to 19,700 [3]	A	NA	38.0	25	29	33	36	42	55	55
	B	NA	38.0	20	24	28	32	35	36	36
21,200 to 23,600 [3]	A	NA	38.0	25	29	33	36	42	55	55
	B	NA	38.0	20	24	28	32	35	36	36
31,000 to 31,300 [7] [8]	NA	4.0	38.0	NA	NA	NA	NA	NA	NA	NA
27,500 to 29,500	A	NA	38.0	25	29	33	36	42	55	55
	B	NA	38.0	20	24	28	32	35	36	36
38,600 to 40,000	A	NA	38.0	25	29	33	36	42	55	55
	B	NA	38.0	20	24	28	32	35	36	36

[1] Except for frequencies listed in § 94.65(a)(1), where omnidirectional antennas may be used.
[2] Except for 2,150–2,180 MHz, where the maximum beamwidth is 360 degrees.
[3] Except as provided for in paragraph (h) of this section.
[4] Antennas used at outlying stations as part of a central protection alarm system need conform to only the following 2 standards: (1) The minimum on-beam forward gain must be at least 10 dBi, and (2) the minimum front-to-back ratio must be at least 20 dB.
[5] Except as provided in § 94.91.
[6] Except for temporary-fixed operations in the band 13200 MHz–13250 MHz with output powers less than 250 mW and as provided in § 94.90.
[7] The minimum front-to-back ratio shall be 38 dBi.
[8] Mobile, except aeronautical mobile, stations need not comply with these standards.
[9] Except for such antennas between 140° and 180° authorized or pending on January 1, 1989 for which minimum radiation suppression to angle (in degrees) from centerline of main beam is 36 decibels.

NOTE: Stations in this service must employ an antenna that meets the performance standards for Category A, except that, in areas not subject to frequency congestion antennas meeting standards for Category B may be employed. Note, however, that the Commission may require the use of a high performance antenna where interference problems can be resolved by the use of such antennas.

(c) Applicants shall request, and authorization for stations in this service will specify, the polarization of each transmitted signal. When periscope antenna systems or passive repeaters are employed, the applicant shall indicate the expected polarization of the reflected signal. The polarization should be expressed as either horizontal, vertical, or at an angle from verti-

cal. Antenna polarizations of horizontal and vertical should be denoted by the abbreviations (H) and (V), respectively. For antennas using linear polarizations other than horizontal or vertical, the polarization should be stated in degrees measured from the vertical, with angles between 0° and +90° denoting the on-coming electric field vector displacement in a counterclockwise direction, and angles between 0° and −90° denoting the on coming electric field vector displacement in a clockwise direction. In the event polarization diversity is authorized, the two polarizations must be separated by 90°. Antennas employing other than linearly polarized feed systems will not be authorized except for stations utilizing frequencies listed in § 94.65(a)(1) or under the provisions of § 94.91(i).

(d) New periscope antenna systems will be authorized upon a certification that the radiation, in a horizontal plane, from an illuminating antenna and reflector combination meets or exceeds the antenna standards of this section and, at locations where multiple periscope antennas are employed, that the cross-coupling between periscope antennas is suppressed by an amount equal to or greater than the radiation suppression specified in the standards for angles from the main beam of 140-180° for the particular band and antenna category selected. In no event will periscope antennas be authorized in frequency bands shared with common carriers.

(e) The provisions of paragraphs (a) and (c) of this section shall also apply to passive repeaters employed to redirect or repeat the signal from a station's directional antenna system.

(f) Periscope antennas used at an electric power facility plant area will be excluded from the requirements of paragraphs (b) and (d) of this section on a case-by-case basis where technical considerations preclude the use of other types of antenna systems.

(g) For frequencies listed in § 94.65(a)(1), the maximum beamwidth may be 360 degrees. The provisions of paragraph (b) of this section shall not apply to stations licensed on these frequencies where omnidirectional antennas are used.

(h) Antenna standards for point-to-multipoint channels in the 10.6 GHz and 18 GHz bands excluding operations under § 94.88.

(1) Nodal transmitting antennas may be omnidirectional or directional, consistent with coverage and interference requirements.

(2) The use of horizontal or vertical plane wave polarization, or right hand or left hand rotating elliptical polarization must be used to minimize harmful interference between stations.

(3) Directive antennas shall be used at all user stations and shall be elevated no higher than necessary to assure adequate service. The user station antennas shall meet the performance standards as specified in § 21.208(c) of this chapter and have a minimum power gain of 34 dBi in the 10,550-10,680 MHz band and 38 dBi in the 17,700-19,700 MHz band. User antenna heights shall not exceed the height criteria of part 17 of this chapter, unless authorization for use of a specific maximum antenna height (above ground and above sea level) for each location has been obtained from the Commission prior to the erection of the antenna. Requests for such authorization shall show the inclusive dates of the proposed operation. (See part 17 of this chapter concerning the construction, marking and lighting of antenna structures).

(Secs. 4, 303, 48 Stat., as amended, 1066, 1082, 1083 (47 U.S.C. 154; 303, 307))

[40 FR 20928, May 13, 1975, as amended at 40 FR 53397, Nov. 18, 1975; 45 FR 55734, Aug. 21, 1980; 46 FR 9955, Jan. 30, 1981; 54 FR 1942, Jan. 18, 1989; 54 FR 10331, Mar. 13, 1989; 55 FR 9730, Mar. 15, 1990; 56 FR 57822, Nov. 14, 1991]

§ 94.77 Interference to geostationary-satellites.

These limitations are necessary to minimize the probability of harmful interference to reception in the bands 2655-2690 MHz, 6425-6875 MHz, and 12.7-12.75 GHz on board geostationary-space stations in the fixed-satellite service (part 25). Stations authorized prior to July 1, 1976 in the band 2655-2690 MHz, which exceed the power levels in paragraphs (a) and (b) of this section are permitted to operate indefinitely, provided that the oper-

ations of such stations does not result in harmful interference to reception in these band on board geostationary space stations.

(a) *2655 to 2690 MHz and 6425 to 6875 MHz.* No directional transmitting antenna utilized by a fixed station operating in these bands shall be aimed within 2 degrees of the geostationary-satellite orbit, taking into account atmospheric refraction. However, exception may be made in unusual circumstances upon a showing that there is no reasonable alternative to the transmission path proposed. If there is no evidence that such exception would cause possible harmful interference to an authorized satellite system, said transmission path may be authorized on waiver basis where the maximum value of the equivalent isotropically radiated power (EIRP) does not exceed:

(1) −47 dBW for any antenna beam directed within 0.5 degrees of the stationary satellite orbit or (2) +47 to +55 dBW, on a linear decibel scale (8 dB per degree) for any antenna beam directed between 0.5 degrees and 1.5 degrees of the stationary orbit.

(b) *12.7 to 12.75 GHz.* No directional transmitting antenna utilized by a fixed station operating in this band shall be aimed within 1.5 degrees of the geostationary-satellite orbit, taking into account atmospheric refraction. However, exception may be made in unusual circumstances upon a showing that there is no reasonable alternative to the transmission path proposed. If there is no evidence that such exception would cause possible harmful interference to an authorized satellite system, said transmission path may be authorized on waiver basis where the maximum value of the equivalent isotropically radiated power (EIRP) does not exceed +45 dBW for any antenna beam directed within 1.5 degrees of the stationary satellite orbit.

(c) Methods for calculating the azimuths to be avoided may be found in: CCIR Report No. 393 (Green Books), New Delhi, 1970; in "Radio-Relay Antenna Pointing for controlled Interference With Geostationary-Satellites" by C. W. Lundgren and A. S. May, *Bell System Technical Journal*, Vol. 48, No. 10, pp. 3387-3422, December 1969; and in "Geostationary Orbit Avoidance Computer Program" by Richard G. Gould, Common Carrier Bureau Report CC-7201, FCC, Washington, DC, 1972. This latter report is available through the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22151, in printed form (PB-211 500) or source card deck (PB-211 501).

[52 FR 7147, Mar. 9, 1987]

§ 94.79 Minimum path lengths for fixed links.

(a) The distance between end points of a fixed link must equal or exceed the value set forth in the table below or the EIRP must be reduced in accordance with the equation set forth below.

Frequency band (MHz):	*Minimum path length (km)*
Below 1,850	N/A
1,850 to 2,110	17
6,425 to 7,125	17
12,200 to 13,250	5
Above 17,700	N/A

(b) For paths shorter than those specified in the Table, the EIRP shall not exceed the value derived from the following equation.

$EIRP = 30 - 20 \log[A/B]$, dBW

Where:

EIRP = equivalent isotropic radiated power in dBW.

A = Minimum path length from the Table for the frequency band in kilometers.

B = The actual path length in kilometers.

(c) Upon an appropriate technical showing, applicants and licensees unable to meet the minimum path length requirement may be granted an exception to these requirements.

[NOTE.—Links authorized prior to April 1, 1987, need not comply with this requirement.]

[52 FR 7147, Mar. 9, 1987]

§ 94.94 Microwave digital modulation.

Microwave transmitters employing digital modulation techniques in the bands 10,550-10,680 and 17,700-19,700 MHz shall transmit at bit rate, in bits per second (bps), equal to or greater than the authorized bandwidth in Hertz (e.g., to be acceptable, equipment transmitting at a 20 Mbps rate must not require an authorized bandwidth greater than 20 MHz). In the 17,700-19,700 MHz band, this bps/Hz standard is independent of the antenna (polarization) used, frequency reuse, or how the system is configured.

NOTE: Until December 1, 1988, no minimum bit rate shall apply to the 17,700-19,700 MHz band. Systems authorized prior to that date may install equipment after that date with no minimum bit rate.

(Secs. 4(i), 301 and 303(r), Federal Communications Act of 1934, as amended, 47 U.S.C. 4(i), 301 and 303(r))

[49 FR 37782, Sept. 26, 1984]